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EFFECT OF INJECTION PRESSURE AND INJECTION TIMING IN PERFORMANCE AND EMISSION CHARACTERISTICS IN DI ENGINE USING BLEND OF METHYL ESTERS OF ALGAE

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ABSTRACT

In the study on "Performance and Emission Studies on a four stroke internal-combustion engine mistreatment alkyl organic compound of algae oil with EGR", a detailed investigation of characteristics (performance and emission) of Blends of alkyl Esters of protoctist oil by varying the EGR management price (5 to 20%) mistreatment with direct injection internal-combustion engine was made. From the preceding studies on similar title, it has been established that the discharge in Night is higher in protoctist, primarily based on biodiesel. This paper from the present study focuses on the Night emission, and the way it is reduced by mistreatment with the cooled EGR.

***KEYWORDS:** Methyl Esters, Alkyl Esters, Algae Oil, Emission & EGR*

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Original Article

1. INTRODUCTION

1.1 The Biodiesel

Renewable energy is the best solution to address both energy and environmental problems. An alternative for diesel fuel is biodiesel, produced through the process of transesterification with least impact on the environment. Catalyst is part of this process, wherein vegetable oils and animal fats react with alcohol. The fatty acid alkyl esters produced through the reaction is called as biodiesel.

In contrast to the diesel, biodiesel possess higher viscosity, density, pour point, flash point in certain number, and on a mass basis its energy content is about 12% less.

Another positive point of biodiesel is it significantly reduces exhaust emissions. Reports reveal that biodiesel of hundred percent purity releases lower tail pipe exhaust emissions compared to the diesel fuel. And, biodiesel is considered to be sulfur - free fuel with 99% less SO_x release as compared to diesel. The higher oxides of nitrogen (NO_X) are released with biodiesel, which is hundred percent pure.

1.2 Transesterification Process

This process is generally used in the production of biodiesel. With catalyst presence, the fatty acid alkyl ester is formed, as fatty acid in vegetable oil reacts with an alcohol such as methanol.

1.3 Pollution Control Techniques

Air injection exhaust gas is being circulated again, and catalytic converters are few important techniques used for pollution control (Senthil et al) (3).

1.4 Exhaust Gas Recirculation Techniques

The cooled EGR is used in this project, since it can curb the NO_X emission. In this technique, the levels of recirculation vary from 5 to 20% EGR check value. EGR limit is controlled with check value having gradient scale around the tuning of value. The varied levels facilitates in finding the corresponding emission level. Then, optimized values are considered for use as finer ALGAE based biodiesel.

1.5 External EGR:

In external EGR system, external piping is used for the circulation of gases from the exhaust manifold to the intake port, which enables recirculation.

In order to match operating conditions, the EGR value can be turned off. NO_X emission can be significantly reduced through this technology. External piping, by pass lines and related cooling mechanisms are some of the additional parts necessary for efficiently operating many external EGR systems. The corrosion of system components can also be exacerbated through the combustion of exhaust gas and moisture in the external piping causing problems of reliability.

1.6 Experimental Apparatus and Procedures

The manufacturer recommended injection timing at 27^0 BTDC (spill). The push rods help in operating overhead valves of the open combustion chamber. Cylinder pressure was measured with piezoelectric pressure transducer mounted on the cylinder head surface.

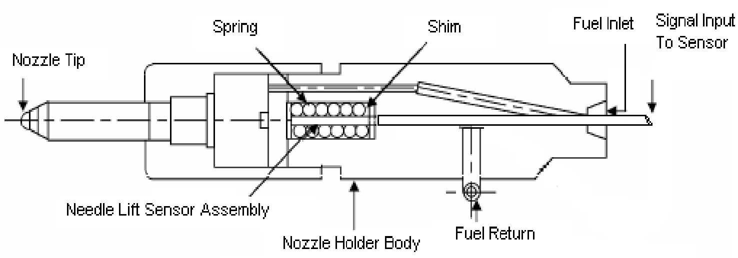

Figure 1: Needle Lifter Sensor Installation Position

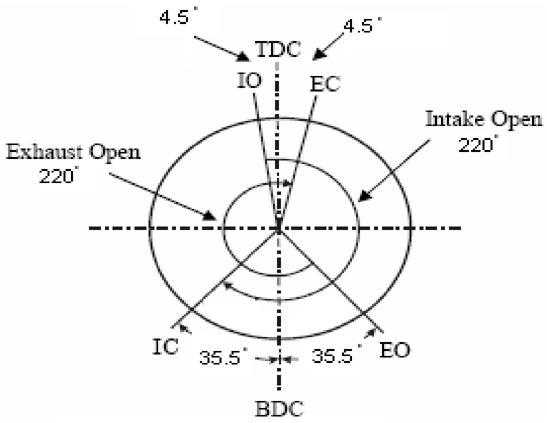

Figure 2: Valve Timing of Test Engine

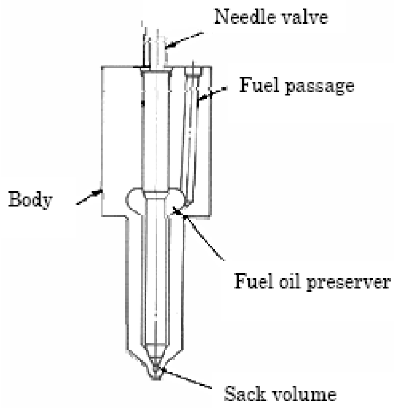

Figure 3: Injection Nozzle

Figure 4: Pressure Transducer of Test Engine

1.7 Electric Dynamometer

A high speed type electric dynamometer with eddy-current electro brake is used in this study.

1.8 Load and Speed Measurements

At a persistent speed of 1800 rpm, the engine was run. Load cell reading provided the load of the engine, and its speed was checked by utilizing sensor together with digital speed indicator.

1.9 Measurement Devices for consumption of fuel

Diesel tank placed in the panel board supplied the fuel for the engine. The panel board had the burette, so that the fuel to the engine will flow from the burette, whenever the fuel cock was closed. Time taken for 10cc of fuel consumption was noted for the fuel flow rates.

1.10 Temperature Measurement

Using the chrome alumel (K – Type) thermocouples, the temperature of the cooling water inlet, outlet and exhaust

gas was calculated.

1.11 Exhaust Gas Emission Measurements Devices

In this study, measurement of nitrogen oxides (NO_X), hydrocarbon (HC), carbon monoxide (CO) and smoke emissions from the exhaust gas were done.

CRYPTON 290 SERIES EMISSION ANALYSER was used to measure the emissions from the test engine. To measure NO_X, a chemical sensor which is a catalyst fitted next to the oxygen sensor is used. Sample exhaust gases taken from exhaust pipe were passed through a filter, and then entered to the NO_X analyzer. The smoke emission from the test engine was measured by using an opacity (AVL make) type smoke meter.

2. RESULTS AND DISCUSSION

2.1 Brake Thermal Efficiency

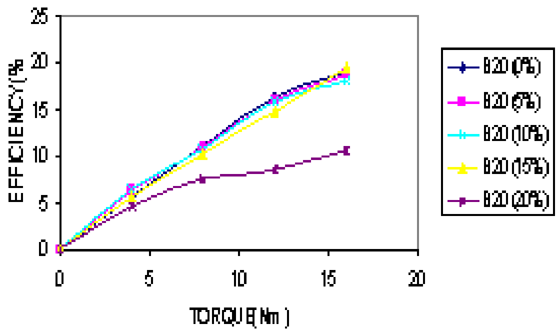

Figure 5: Torque vs Efficiency B20

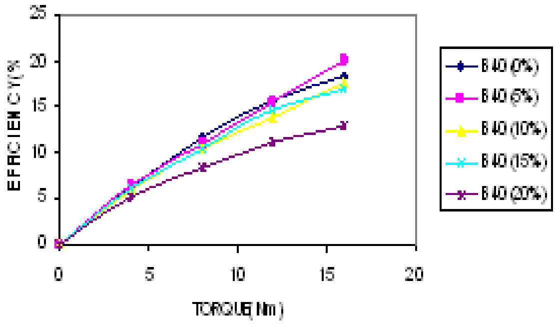

Figure 6: Torque vs Efficiency B40

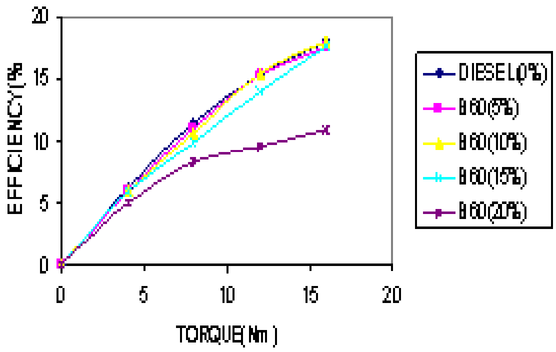

Figure 7: Torque vs Efficiency B60

As shown in Figure 5 to 7, the Brake Thermal Efficiency of engine decreased as biodiesel blends increased. And, rate of efficiency increases as EGR rate is increased and further than 15% EGR level, there is drastic reduction in the BTE.

2.2 Specific Energy Consumption

SEC is used for performance comparison of such engines.

SEC (in kJ/ kWh) = Calorific value of the fuel * Specific fuel consumption

The disparity of specific energy consumption with varied EGR rate along with different fuels that are blended is depicted in graph (Figure 8 to Figure 11). We see that based on the calorific value, the specific energy consumption of fuels increased as blended fuels increased.

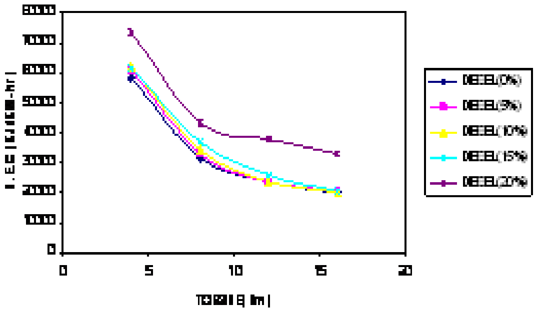

Figure 8: Torque vs S.E.C Diesel

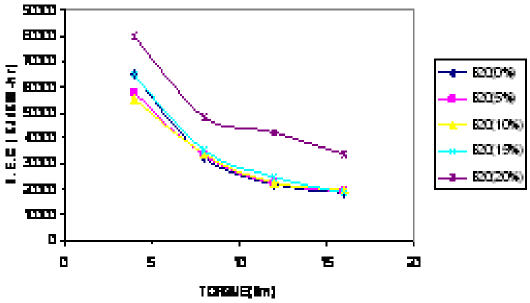

Figure 9: Torque vs S.E.C B20

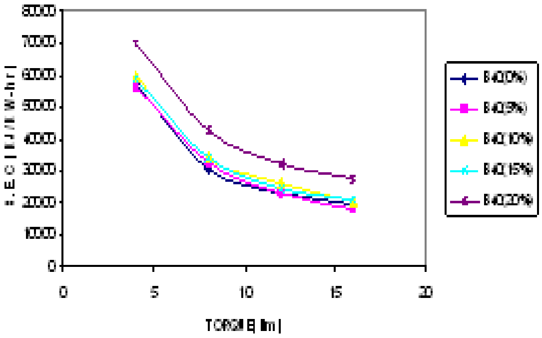

Figure 10: Torque vs S.E.C B40

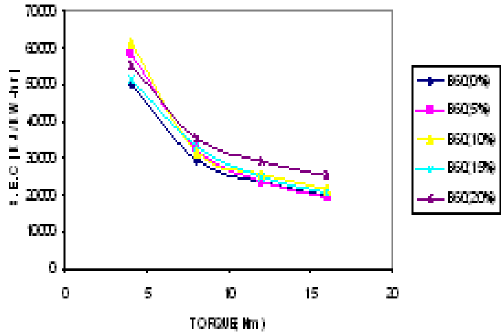

Figure 11: Torque vs S.E.C B60

2.3 Emission Characteristics of the Engine

2.3.1 Carbon Monoxide (CO)

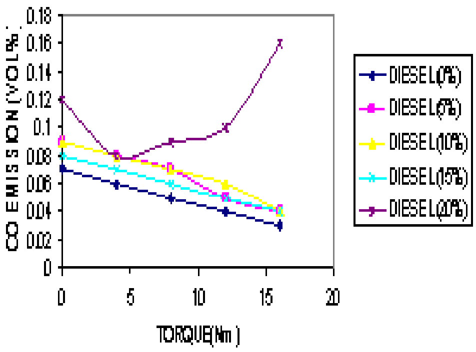

Figure 12: Torque vs CO Diesel

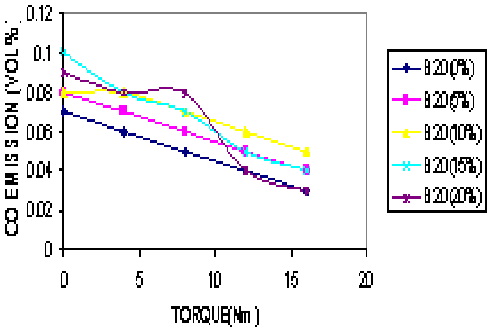

Figure 13: Torque vs CO B20

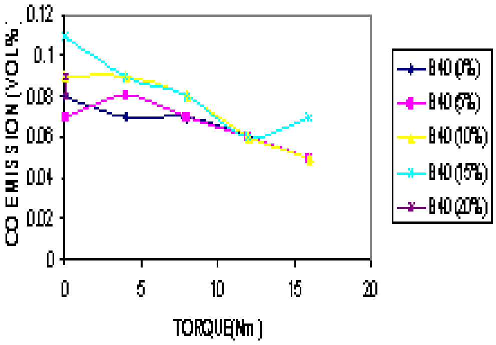

Figure 14: Torque vs CO B40

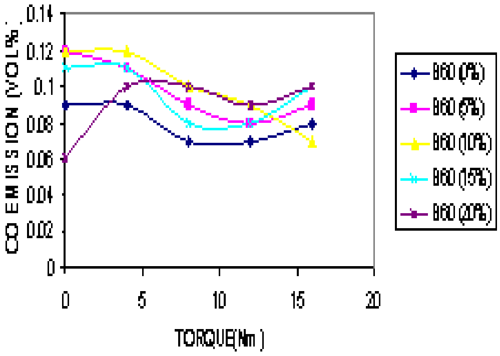

Figure 15: Torque vs CO B60

Variation in CO with various EGR levels is shown in the graph (Figure 12 to Figure 15). When compared to diesel emission, the release of CO from bio-diesel was lower. The CO levels increased with EGR. When operating under oxygen in scarce condition, there is a higher CO value for diesel under higher EGR, whereas, deficiency of oxygen is partly compensated with the surplus oxygen for bio-diesel under EGR. The reason for higher CO emissions can be on account of disintegration of CO_2 to CO when loads reach its climax. During this time, the combustion temperatures become high and comparatively fuel rich operation exists.

2.4 Unburned Hydrocarbons (HC)

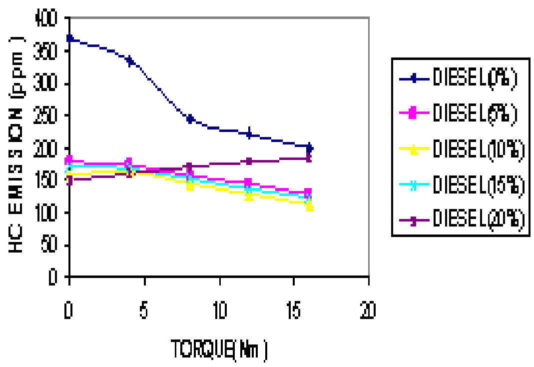

Figure 16: Torque vs HC Diesel

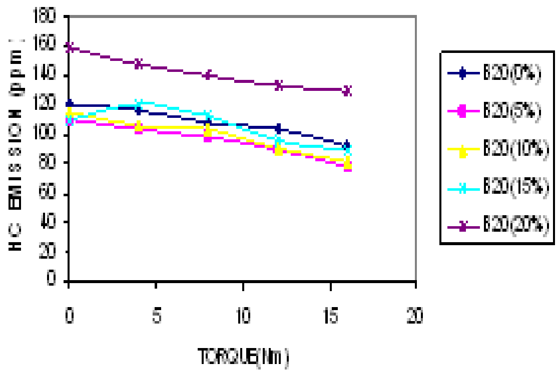

Figure 17: Torque vs HC B20

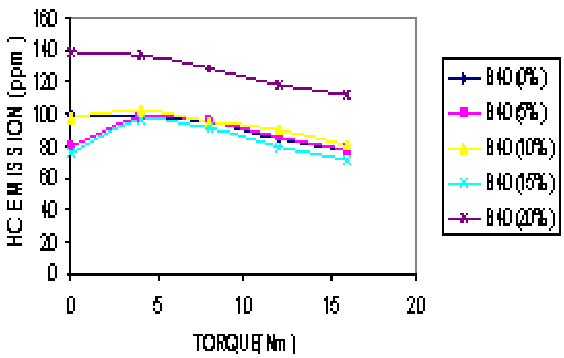

Figure 18: Torque vs HC B40

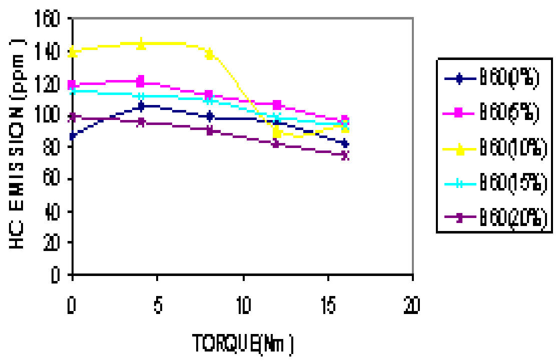

Figure 19: Torque vs HC B60

The graph (Figure 16 to Figure 19) shows variation of HC emission with EGR rate. Even as EGR level was increased for bio-diesel, there was no drastic increase in HC. It could be because of the surplus oxygen in bio-diesel, making it up for the shortage of oxygen, which further facilitates the process of complete combustion. The variation over this range was only 10–40 ppm for bio-diesel. As the EGR rate was increased, the bio-diesel blends emission reduced. B40 (15% EGR) is the least value of the HC emission.

2.5 Oxides of Nitrogen (NO_X)

The variation of NO_X emissions with various EGR rate for the whole load range is shown in the graph (Figure 20 to Figure 23). Emission of NO_X increased with increase in the content of biodiesel in the blended fuels. Moreover, NO_X emission from the biodiesel was higher than diesel. The higher oxygen level could be the possible reason for increase in NO_X concentration by about 2 to 10 per cent from biodiesel fuelled engine. As shown in the figure, the NO_X level decreases with the increase in EGR rate. Despite 20 % EGR reducing NO_X significantly, the reduction in BTE, CO increase and HC emissions were observed.

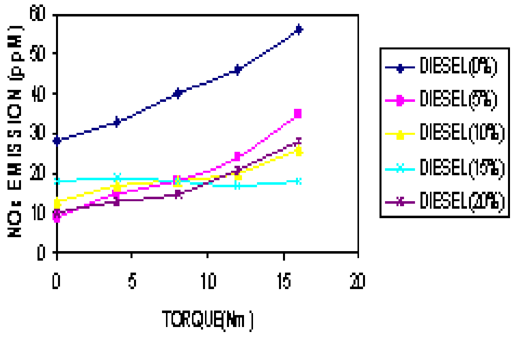

Figure 20: Torque vs NO_X Diesel

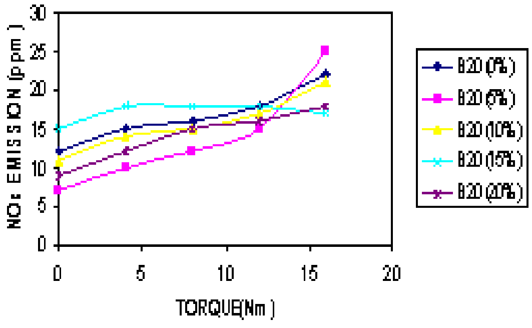

Figure 21: Torque vs NO_X B20

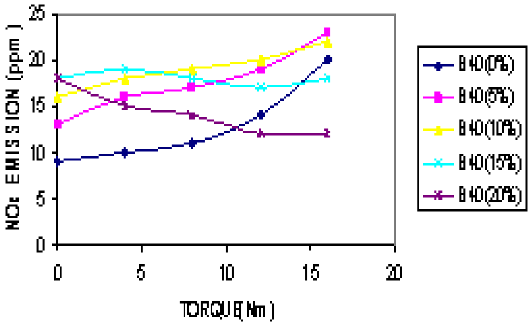

Figure 22: Torque vs NO_X B40

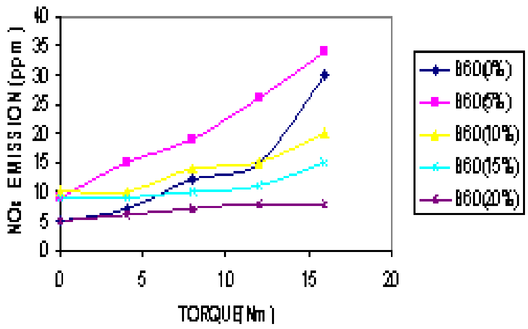

Figure 23: Torque vs NO_X B60

2.6 Cylinder Pressure

There was no EGR condition comparable for both fuels obtained at 3/4 load. Under these conditions, 62 bars (for diesel) and 60 bars (for bio-diesel) was the peak pressure. So, at higher loads with high temperatures, diesel shows a fair blend formation.

2.7 Pressure VS Crank Angle

The percentage of heat input is taken for diesel and various blends with 15% and without EGR. The figure 24 shows the comparison of the crank angle (deg) with Pressure for all fuels blends with 15% and without EGR. The figure shows that the amount of energy supplied increases with pressure. Without EGR, there is minimum value for the engine and with 15% EGR, there is a maximum value.

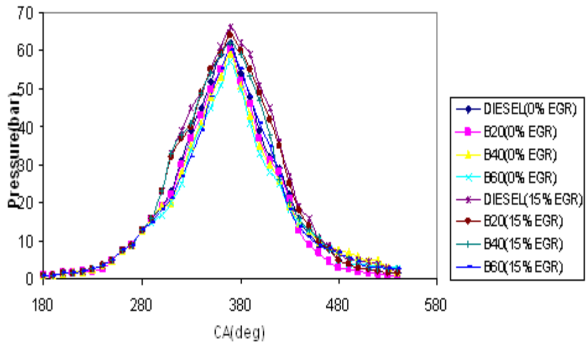

Figure 24: Pressure vs Crank Angle

2.8 Heat Release Rate

Rates of heat release (HRR) are shown in figure 25. For diesel under 3/4 load and 15% EGR, there is faintly higher peak HRR of 79.64 J/deg and 76.34 J/deg for bio diesel. Better premixed combustion can increase heat release rate, which also facilitates increased NO emission. Higher HRR for bio-diesel devoid of EGR is possibly because of the surplus oxygen content in its structure and a dynamic injection advance, apart from static injection advance. With optimized EGR of 15% and without for both fuels is shown.

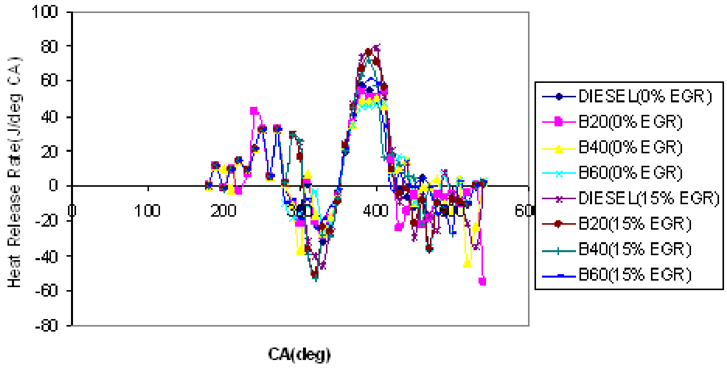

Figure 25: Heat Release Rate vs Crank Angle

2.9 Rate of Pressure Rise

The figure 26 shows that the variation of rate of pressure rises with crank angle, which is indicative of noisy operation of the engine. With optimized EGR of 15% and without for both fuels, the rate of pressure rise were found to be comparable. Peak values at ¾ loads were found to be 1.2 bar/deg. The comparable state is indicative of stable and noise free operation of compression ignition engines with JBD.

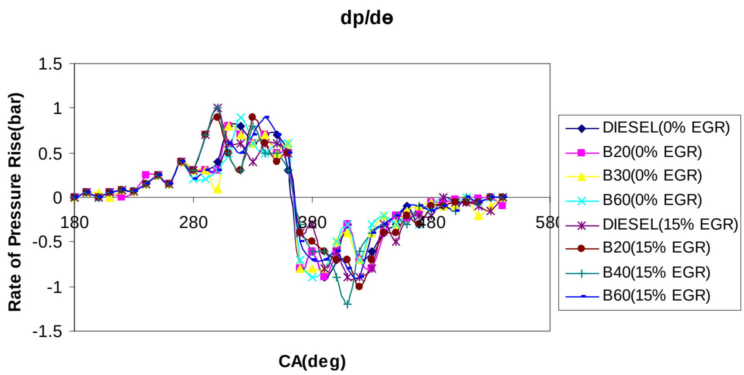

Figure 26: Rate of Pressure Rise (Bar) vs Crank Angle

2.10 Cumulative Heat Release

Without and with optimized EGR of 15%, the cumulative heat release was found to be comparable for both fuels as shown in figure 27. The maximum cumulative heat release rate for diesel with EGR of 15% is 415.29 j/deg.

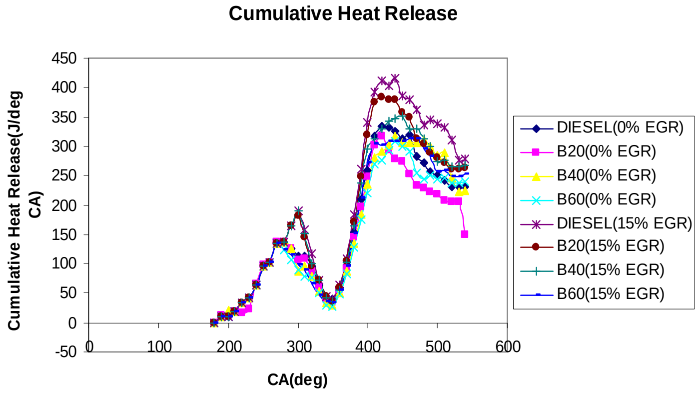

Figure 27: Cumulative Heat Release vs Crank Angle

3. CONCLUSIONS

In this study, Methyl Esters of ALGAE oil (MEJ) and its mixture were tested with Kirloskar Engine. It was then compared with traditional commercial diesel fuel. Biodiesel and its blends showed a faintly less brake thermal efficiency as compared to diesel fuel at tested load conditions. Specific Energy Consumption of fuels increases with increase in the amounts of blended fuels owing to lower calorific values. It was also found that the release of carbon monoxide (CO) increased as biodiesel blends increased. And, as EGR rate increased, there was a slight decrease in the efficiency of the engine because of higher EGR and CO. In biodiesel, the increase in EGR rate decreased the release of NO_X and HC. It was also found that the release of NO_X and HC from the biodiesel fuel was higher than that of diesel.

For Higher EGR rate, emission is reduced with simultaneous decrease in performance. Therefore, 15% EGR for fuels is favorable to enhance its performance and emission characteristics with various EGR rate.

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